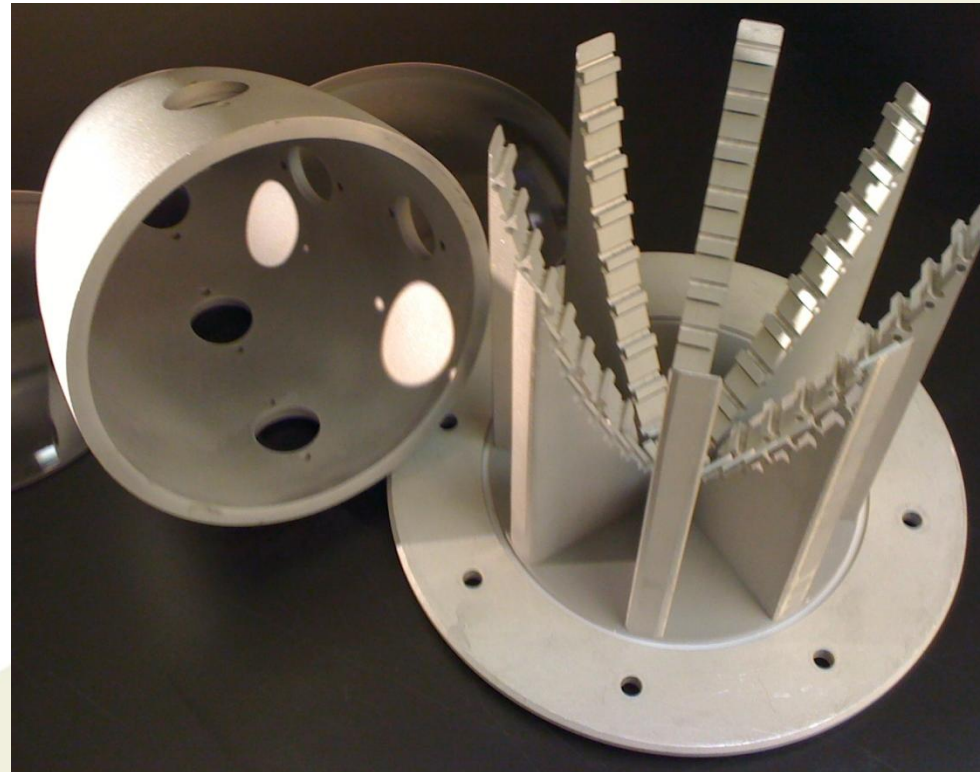


REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
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1. REPORT DATE (DD-MM-YYYY) 07-06-2010		2. REPORT TYPE Conference Proceeding		3. DATES COVERED (From - To) 7/2009 to 7/2011	
4. TITLE AND SUBTITLE Thermally Robust Ion Beam Sputtered Coatings for Deep Concave Surfaces				5a. CONTRACT NUMBER N68936-10-C-0020	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Dale Ness, Darrel Pitrat, Chris Wood, and Mark B. Moran				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Precision Photonics 3180 Sterling Circle Boulder, CO 80301				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Naval Air Warfare Center Weapons Division, China Lake, under contract N68936-10-C-0020, Mark Moran TPOC				10. SPONSOR/MONITOR'S ACRONYM(S) NAVAIR	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES Presented at Mirror Technology Days, Boulder, Colorado, USA, 7-9 June 2010.					
14. ABSTRACT Precision Photonics Corporation has developed a method of applying Ion Beam Sputtered (IBS) MWIR anti-reflective coatings to the interior of a tangent ogive dome. Although IBS has traditionally not been used in this application, it is known that IBS provides the highest density coatings using very hard, durable materials. We achieved a variable coating thickness profile by means of shadow masking coupled with a sophisticated 3 dimensional mathematical model, which optimizes the antireflection performance over a wide range of look angles for an infrared seeker inside the dome. The coating design for this project survives temperatures up to 1000°C.					
15. SUBJECT TERMS mid-wave, infrared, coating, dome, robust, masking, uniformity					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 16	19a. NAME OF RESPONSIBLE PERSON Hans-Peter Dumm
a. REPORT UNCLASSIFIED	b. ABSTRACT UNCLASSIFIED	c. THIS PAGE UNCLASSIFIED			19b. TELEPHONE NUMBER (include area code) 505-853-8397

Thermally Robust IBS Coatings for Deep Concave Surfaces

*Dale Ness, Darrel Pitrat, and
Chris Wood,*

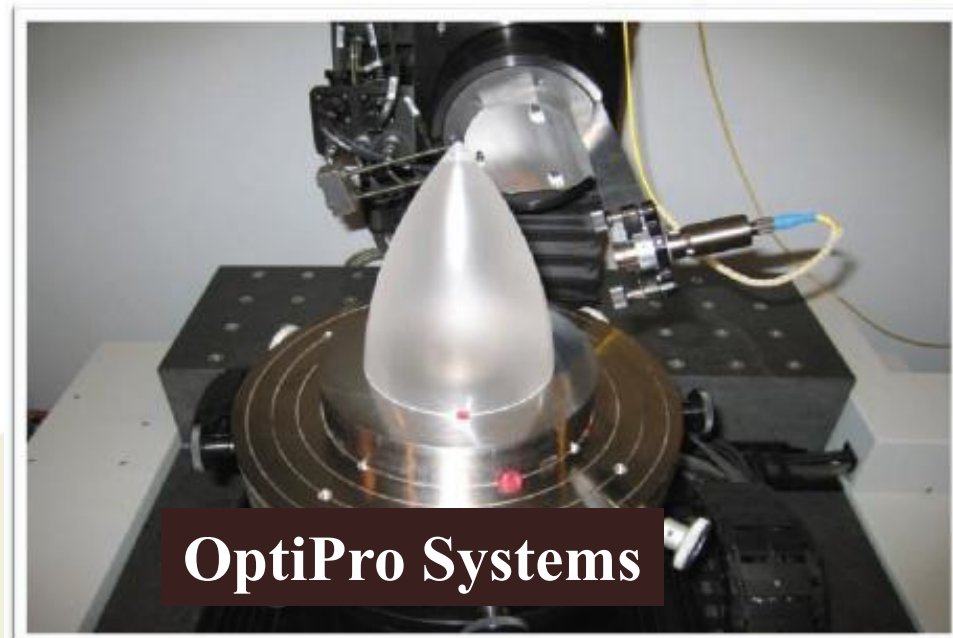
Mark B. Moran, U.S. Navy



This work is supported by the Naval Air Warfare Center Weapons Division, China Lake, under contract N68936-10-C-0020
Distribution A: Approved for Public Release

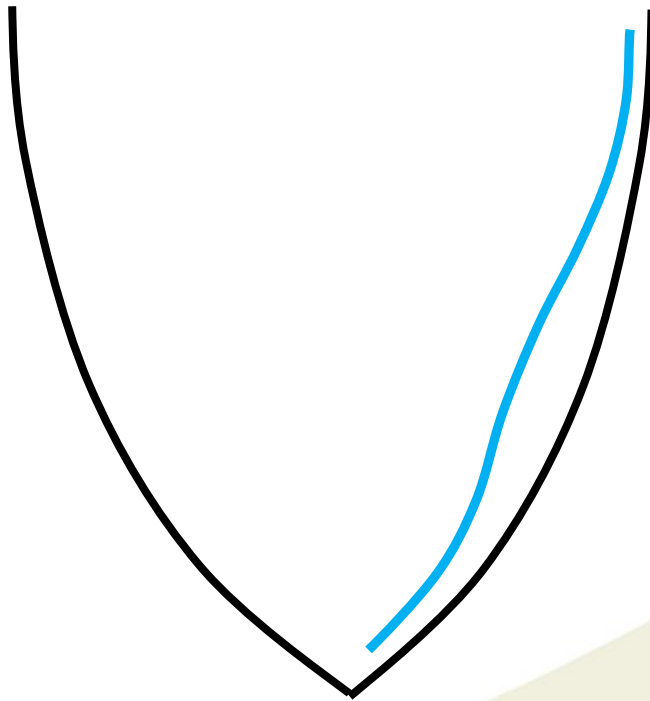
The Challenge

- Dome shape trend: Hemispherical dome → tangent ogive
- Improved aerodynamics:
 - decrease drag, temp., increase range, speed
- Increased durability against rain, etc.
- Increased optical field of regard
- Issues:
 - High temperature operation ($\sim 1000^{\circ}\text{C}$) required
 - more complex optic, more complex coatings necessary
 - Spatially-varying coating profile required in order to optimize AR coating for a wide range of look angles within the dome

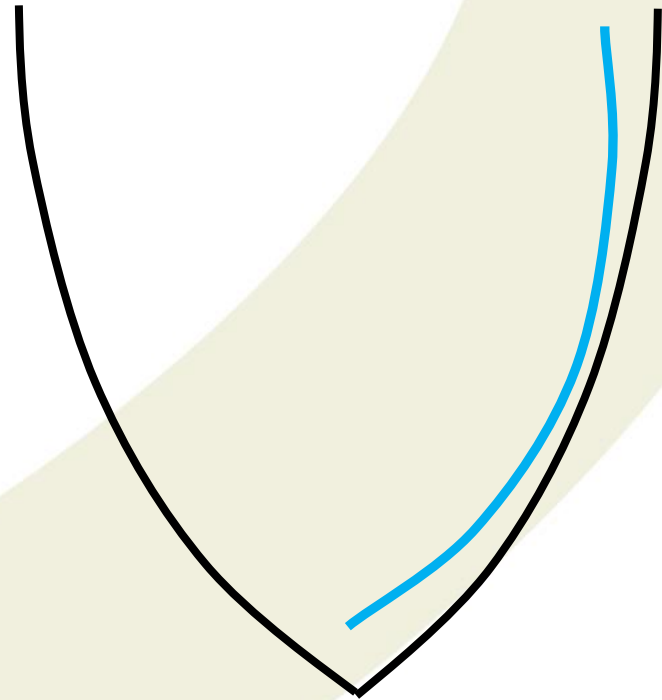


If you just put the dome in a coating chamber...

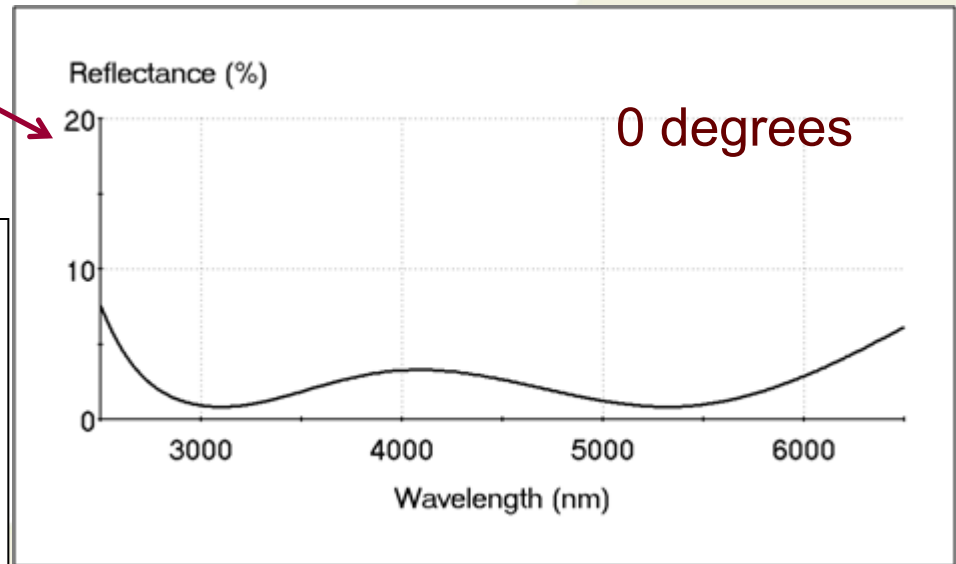
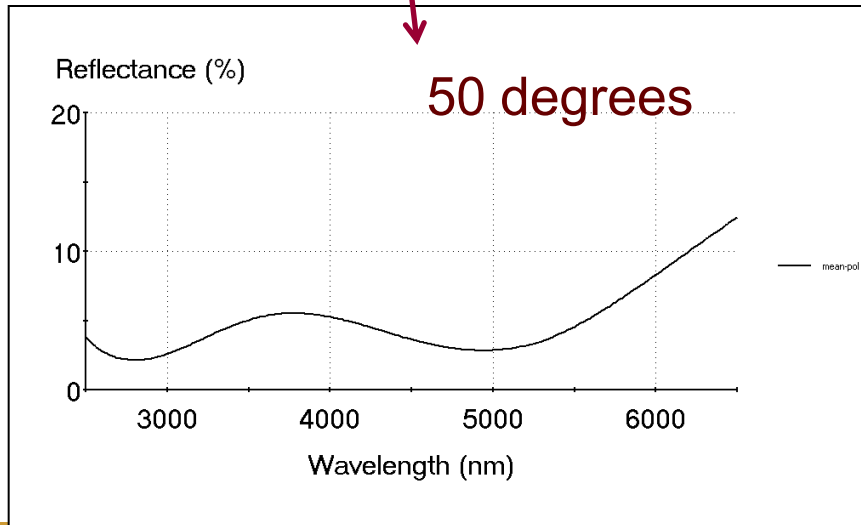
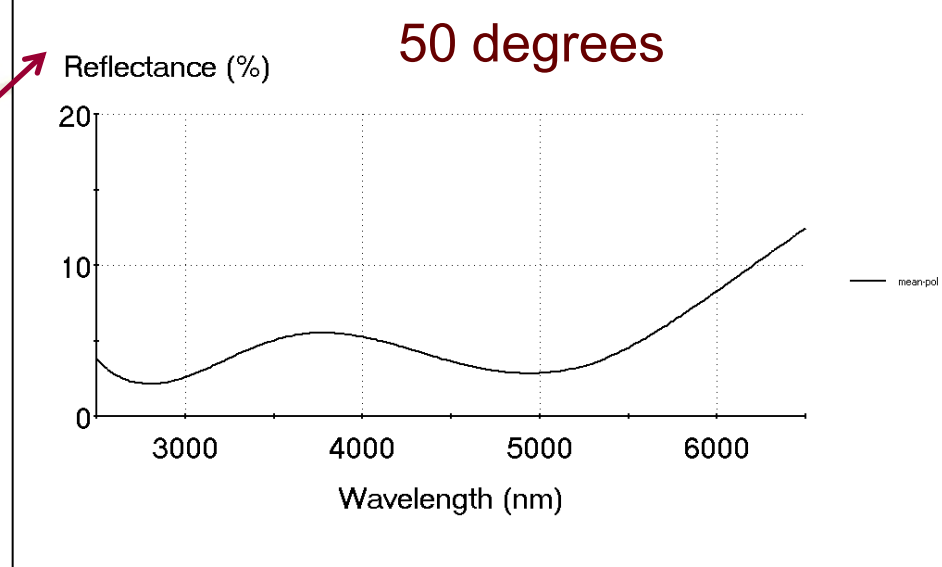
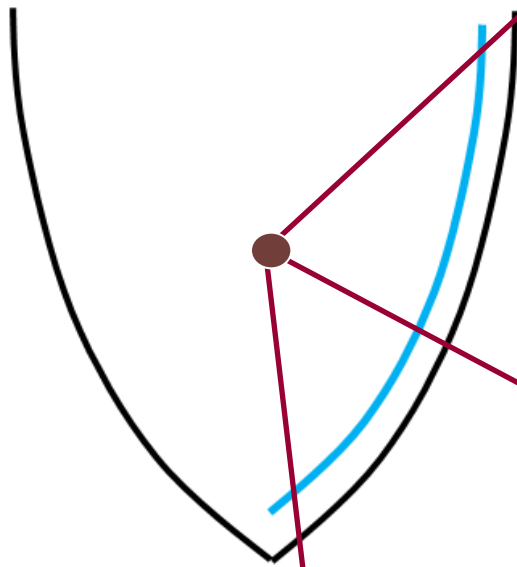
What you get:



What you want:



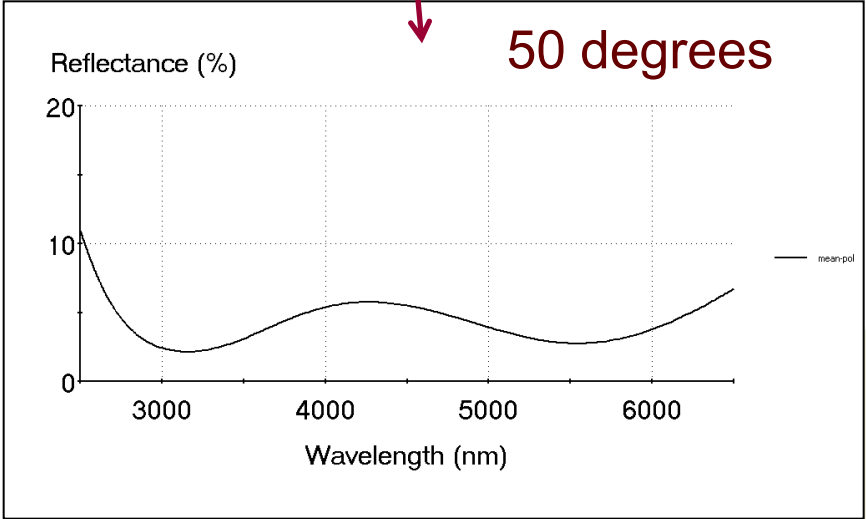
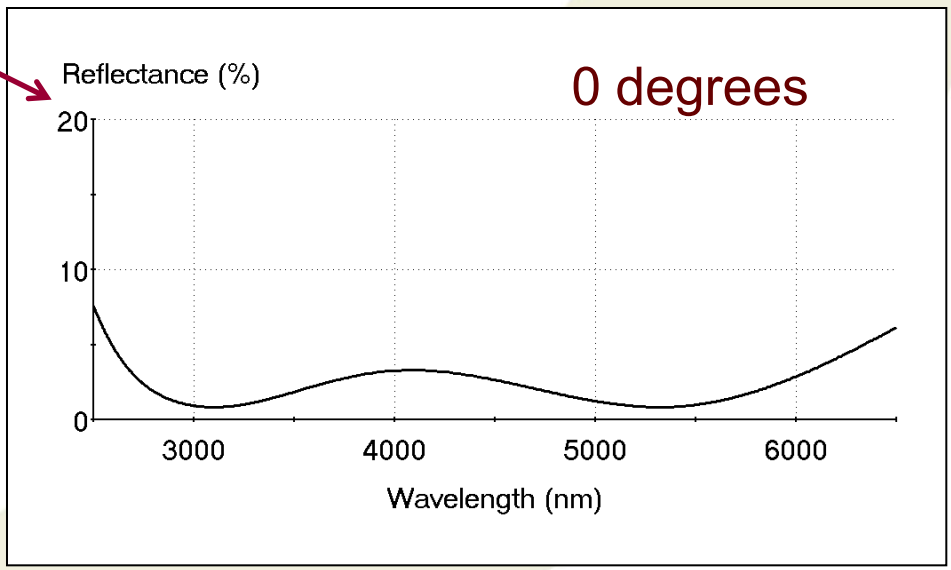
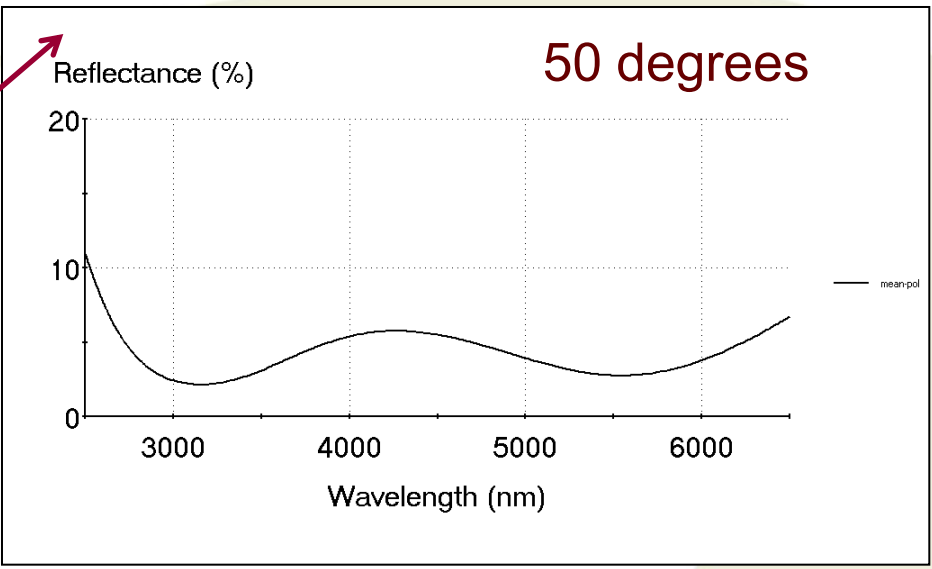
Uniform thickness profile *incorrect*



The coating thickness challenge
(Mean polarization shown)

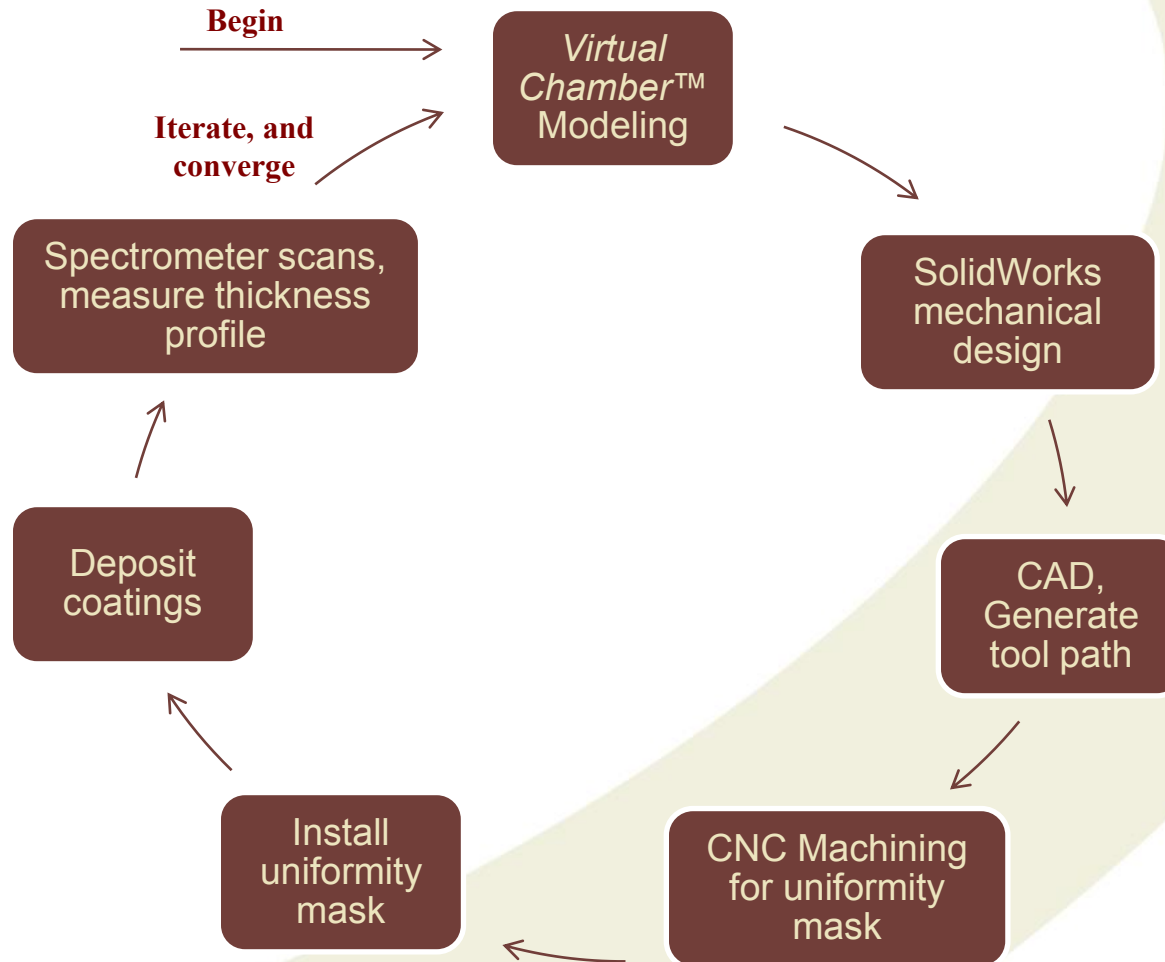
Spatially-varying thickness profile

correct

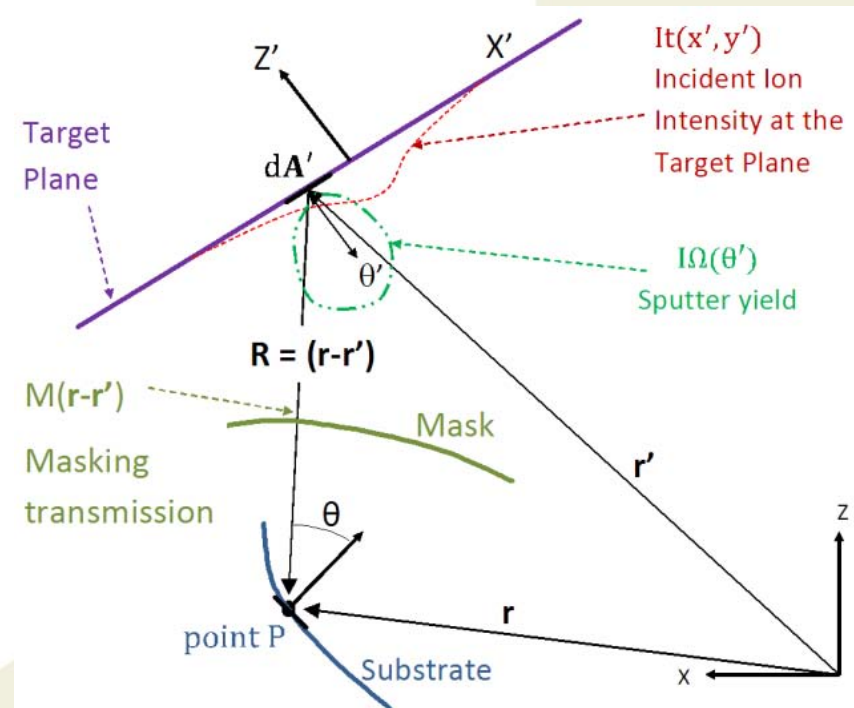
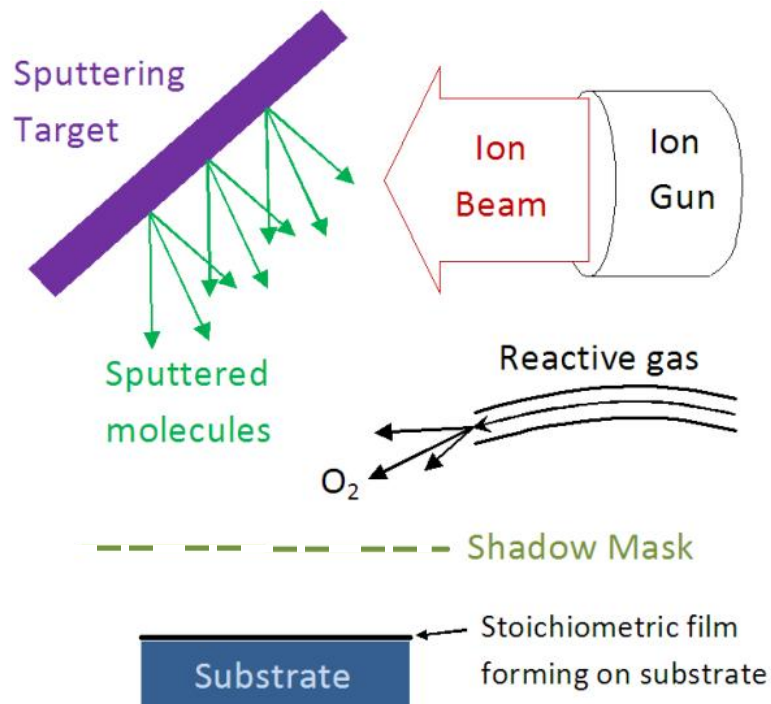


The coating thickness challenge
(Mean polarization shown)

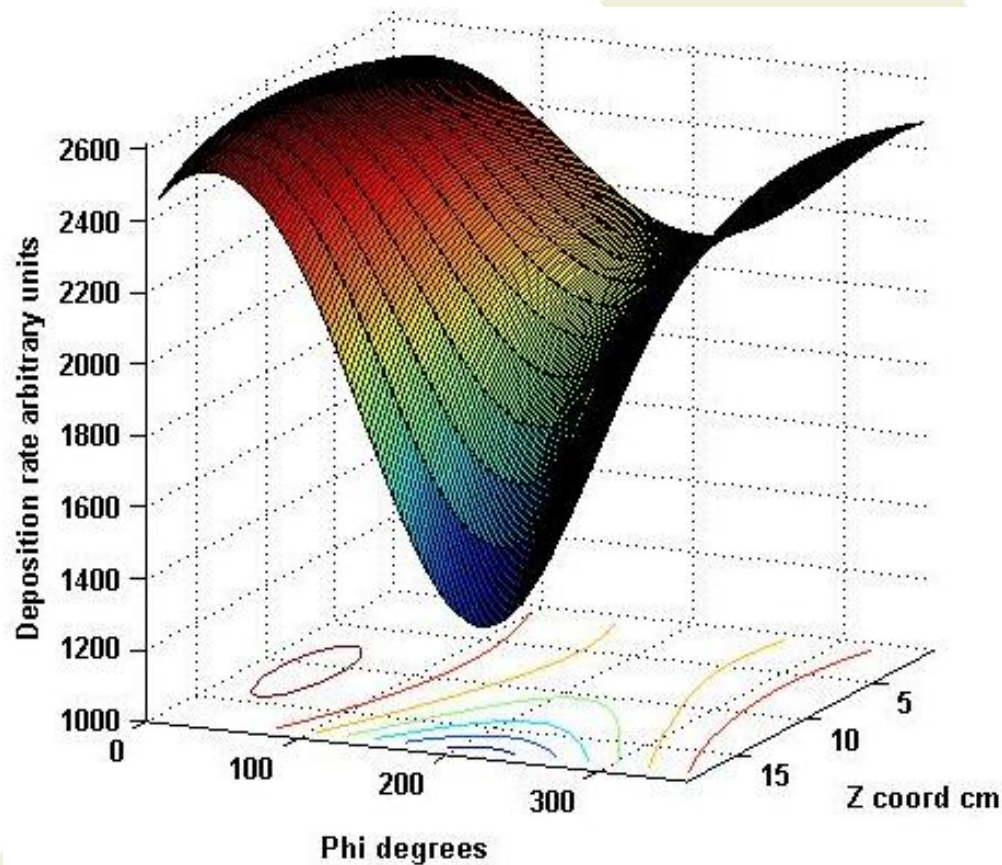
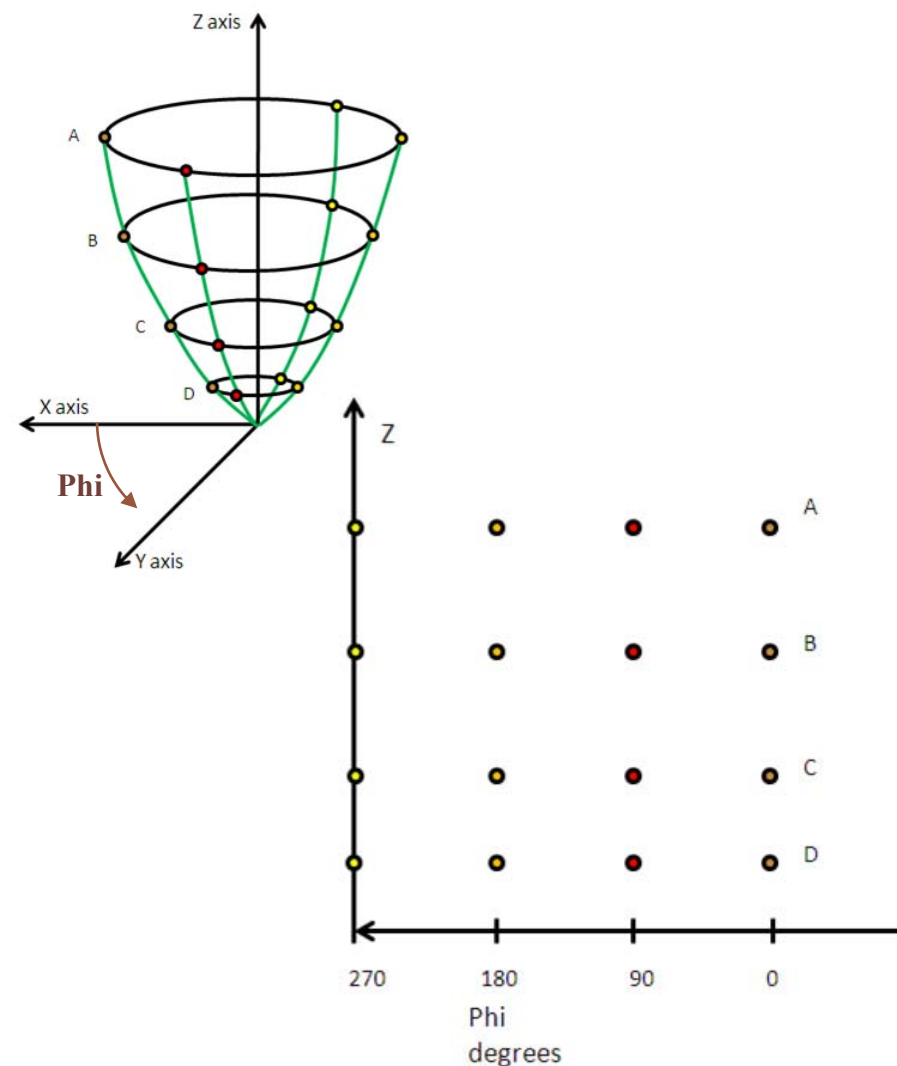
PPC's Solution



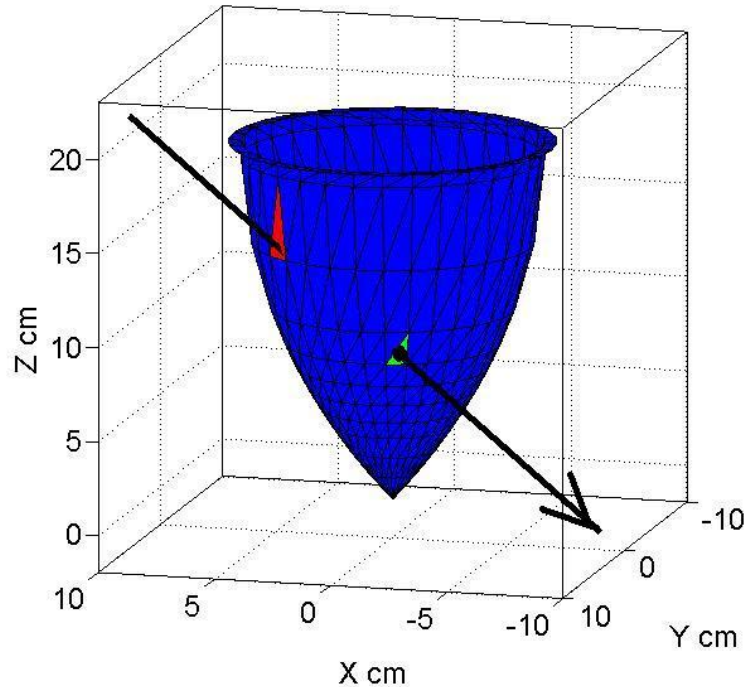
IBS Model: *Virtual Chamber*TM



Virtual Chamber™ → Dome Rate Field



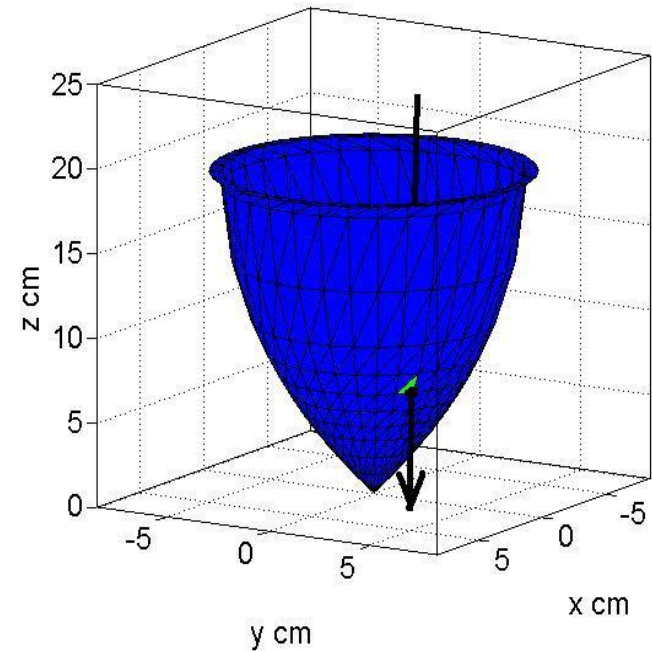
Virtual Chamber™ → Uniformity Masking



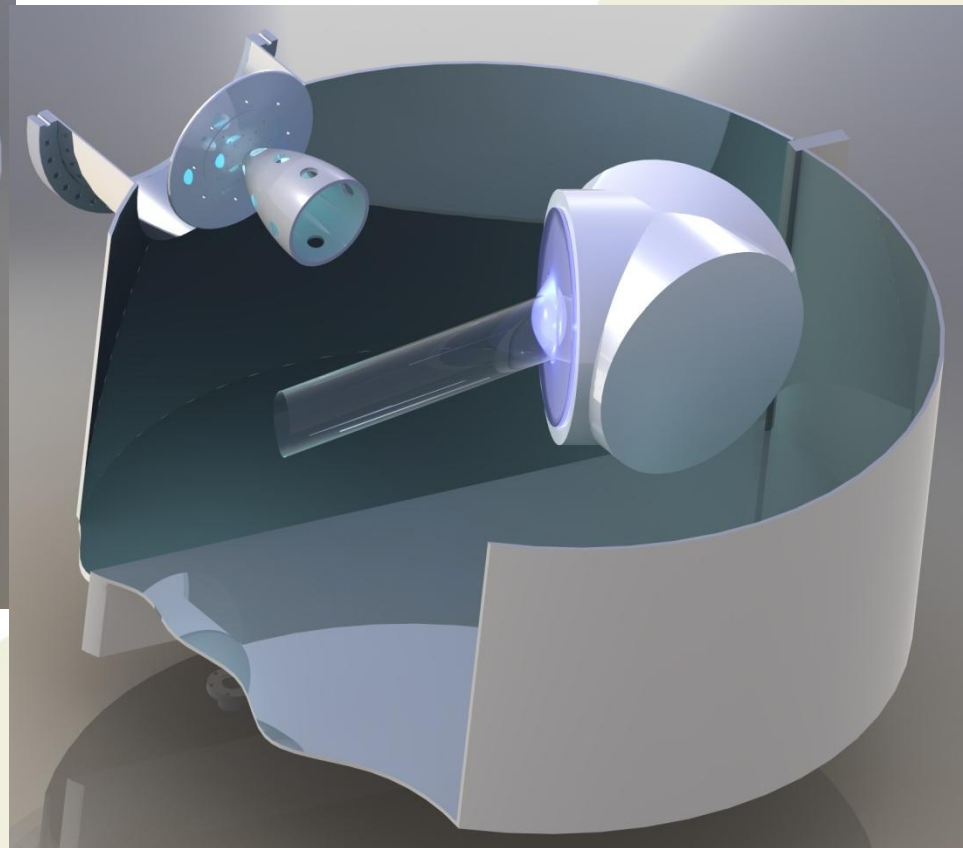
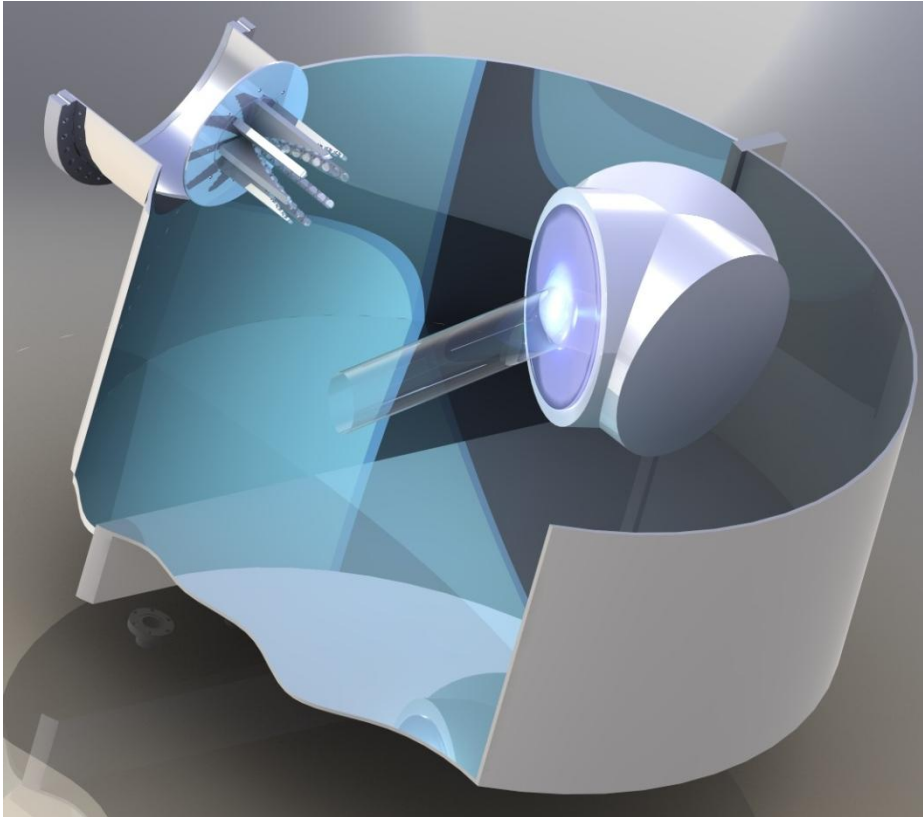
Rays indicate material path from sputtering target to dome surfaces

Goal:

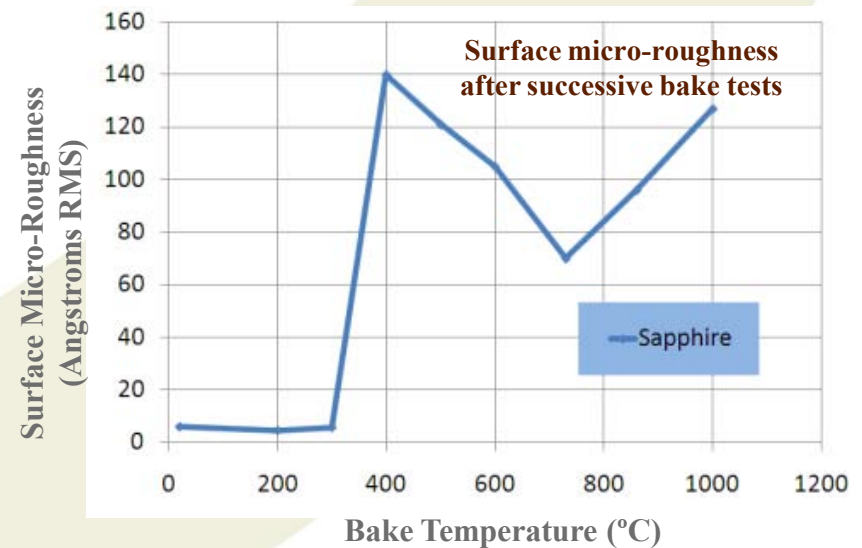
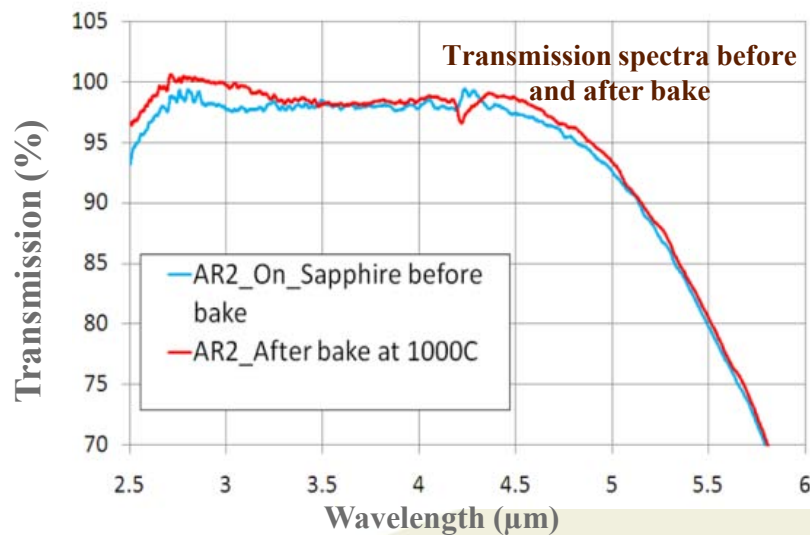
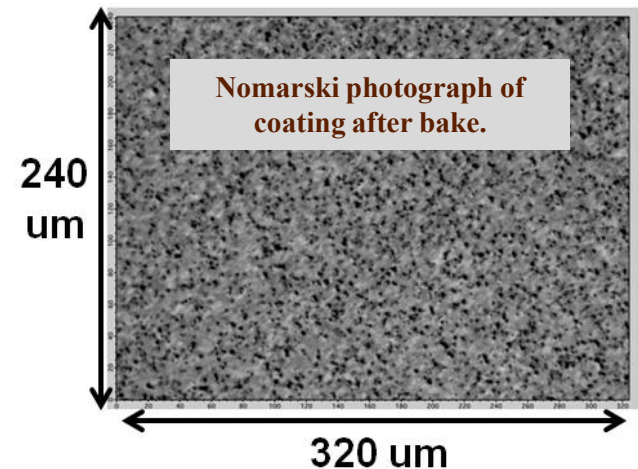
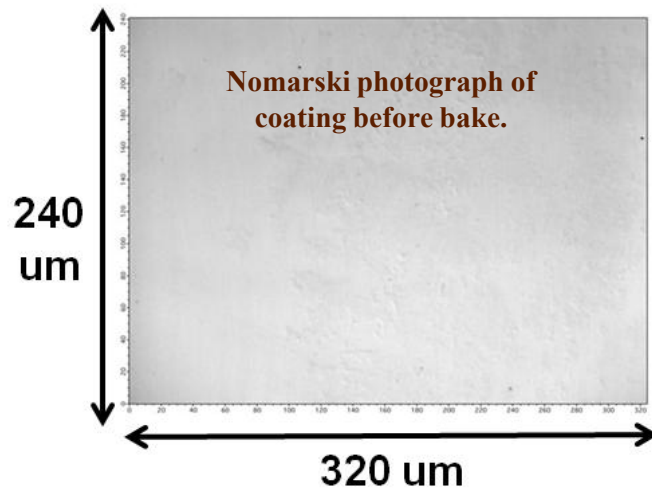
Tailor which 'paths' are allowed to reach the dome surface, as a function of position along the dome interior. Use mechanical masking of sputter distribution to accomplish this



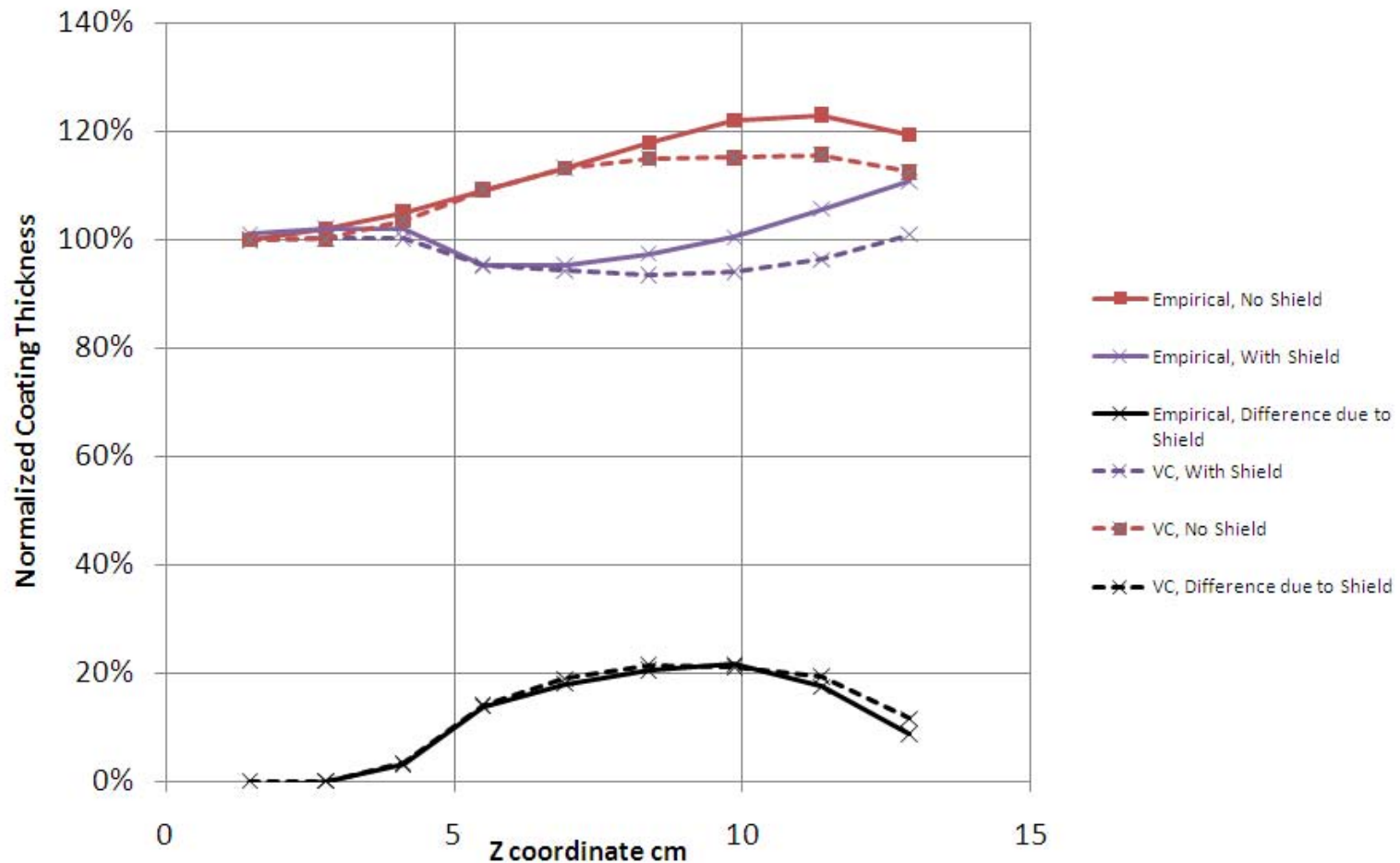
Virtual Chamber™ → SolidWorks



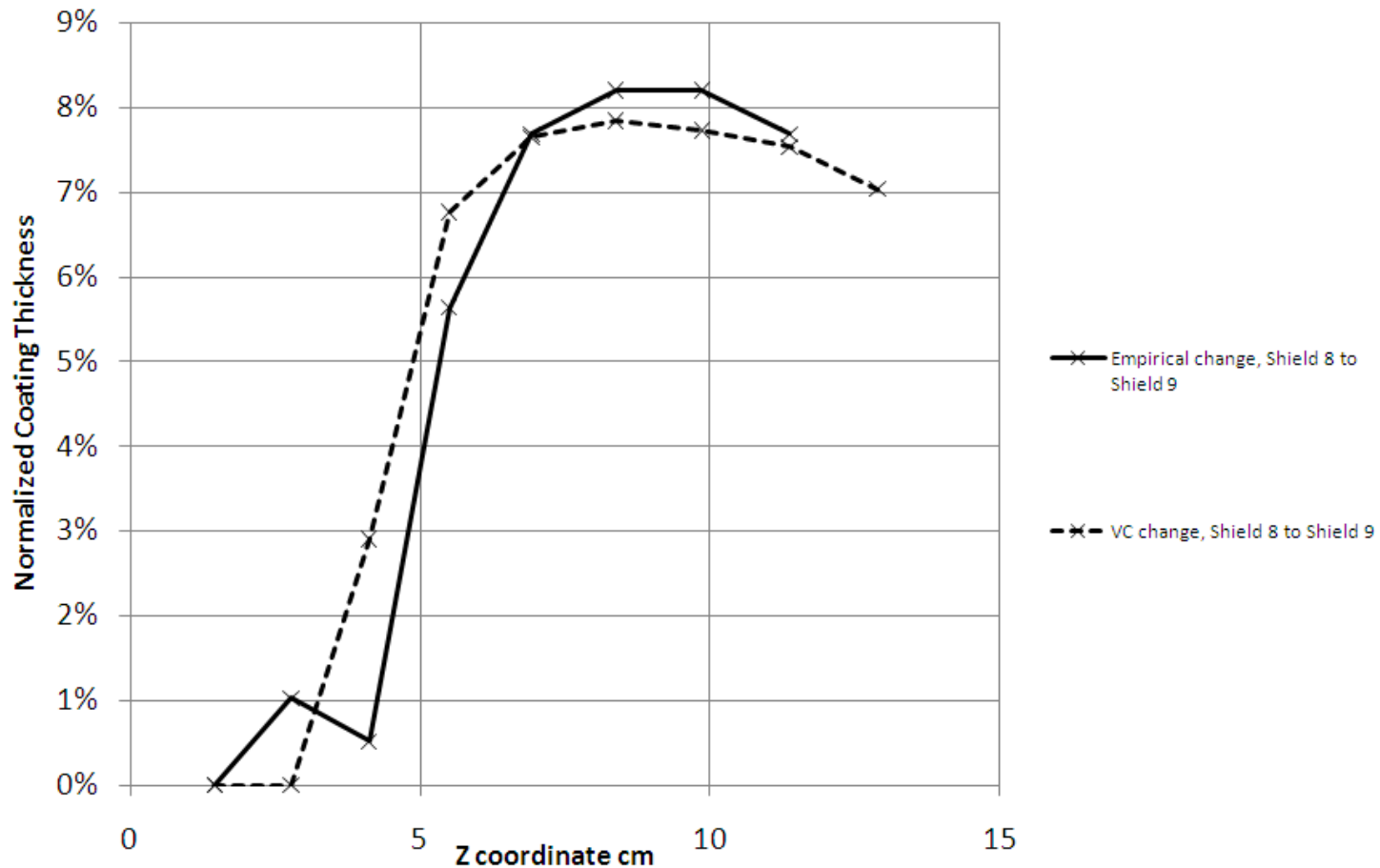
1000°C Operation



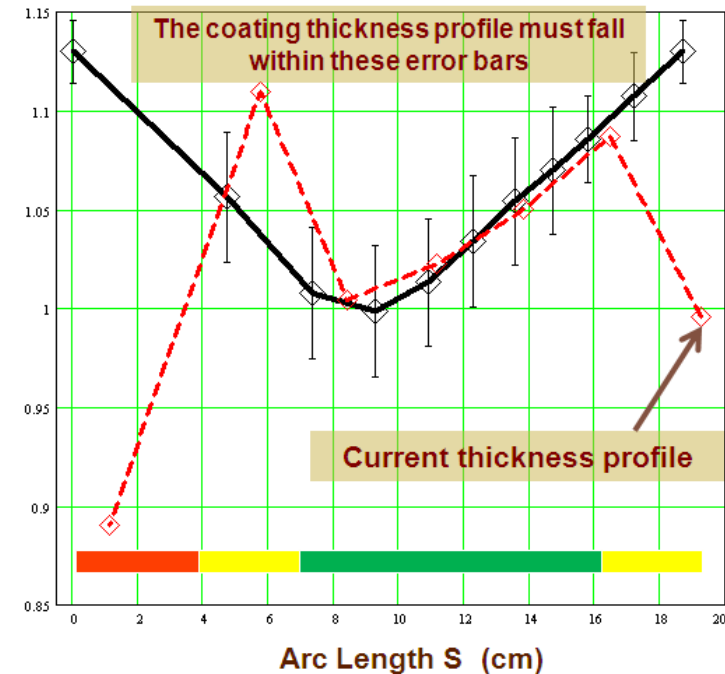
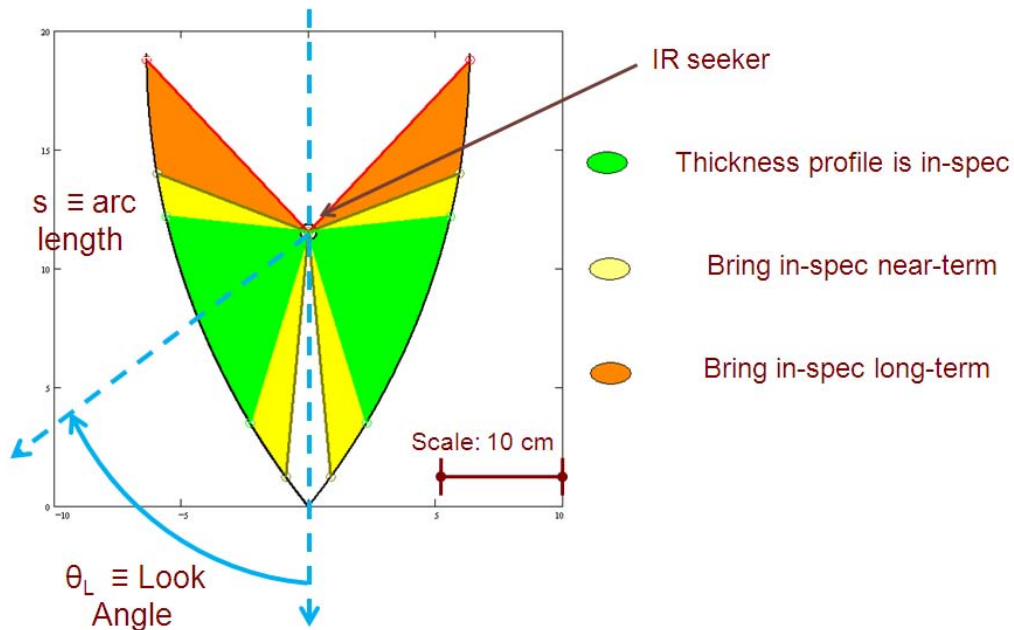
Modeling vs Experiment



Iteration: Old Mask \rightarrow New Mask

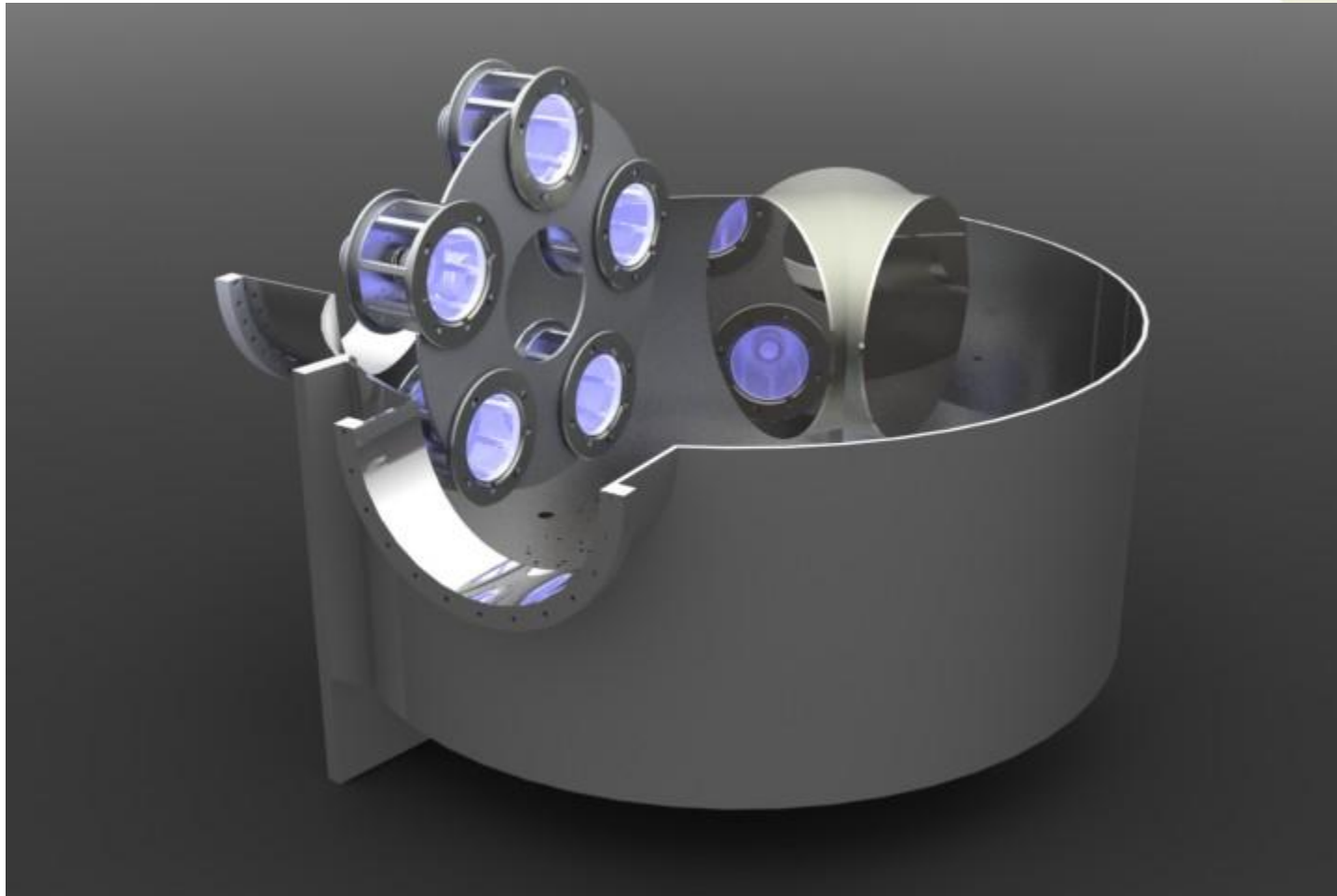


Conclusion and Summary



- Demonstrated a robust AR coating on sapphire that survives exposure to 1000°C
- PPC's *Virtual Chamber*TM model is operational and reliable
- Tooling concept for coating dome interiors works reliably, will be modified for dome exteriors
- Achieved specified coating thickness uniformity over a look angle range of 16° to 96°

Coating Multiple Domes



.....Questions?

Title of Success Story Product/Service

***SBIR Company Name
City, State***

INNOVATION

Brief description of the new technology/application. (Please try to state what the technology does in a clear, plain-spoken manner.)

ACCOMPLISHMENTS

- ◆ Development stage (e.g., prototype, small production runs, etc.).
- ◆ Significant technical achievements and noteworthy business developments to date.
- ◆ Cumulative private capital investment by firm to date (*if not commercially sensitive*).
- ◆ Other evidence of private-sector commitment.

COMMERCIALIZATION

- ◆ Identify product/service name; trademark name.
- ◆ Indicate number of associated patents, patent applications to date.
- ◆ Brief description of primary target market sectors; distinguish actual from potential market sectors.
- ◆ State if product/service currently being sold or available for sale, by market sector; if not, provide expected entry date into market, by market sector.
- ◆ Cumulative sales revenues to date by market sector (*if not commercially sensitive*).
- ◆ Statement regarding other demonstrated customer interest to date.
- ◆ Other associated cumulative revenues generated to date (e.g., from licensing fees, royalties, sell-off of the technology) (*if not commercially sensitive*).
- ◆ Identify venture structure (e.g., new profit center/business segment within existing firm, spinoff entity, joint venture partnership, other strategic alliance).
- ◆ Identify names of joint venture/strategic alliance partner firms (*if not sensitive*).
- ◆ Describe unique competitive advantage of the new technology, with respect to specific, existing customer needs in each target market sector.



Hollow Cathode Plasma Electron Emitters

GOVERNMENT/SCIENCE APPLICATIONS

- ◆ Brief description of the product service for NASA and other USG applications; distinguish between actual and potential applications.
- ◆ Remaining technological or business development necessary for NASA/USG application.
- ◆ Identify NASA and other USG missions utilizing the product/service; distinguish between actual and potential applications.
- ◆ Statement regarding other demonstrated NASA/USG customer interest to date.
- ◆ NASA and/or other USG Phase III contracts (w/\$ amounts).
- ◆ Estimate of NASA mission/project cost savings due to SBIR innovation/product developed.